Techniques for Impact Evaluation of Performance Measurement Systems

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Structured Abstract

Purpose

Organizations often introduce Performance Measurement Systems (PMSs) in order to evaluate the level of their performance, make comparison with competitors, and plan their future activities. Since indicators may affect the behaviour of the monitored system, the design and implementation of a PMS should always include the analysis of the impact it may exert on the organization itself. In this work a methodology to evaluate this impact is suggested.

Design/methodology/approach

The proposed approach is based on an impact reference model derived from the Balanced Scorecard (BSC) framework. The different perspectives of the BSC are interpreted as areas of impact within an organization. Structured steps for impact evaluation are described and specific techniques of analysis are introduced.

Findings

A series of case studies, together with an analysis of advantages and disadvantages of the proposed method, are presented. Results show that, although many sets of indicators are usually able to meet the role of a PMS, they may exert a different impact on the context they are applied. The proposed methodology results to be a useful instrument for choosing the right set of indicators from the impact point of view. Finally, possible research paths to be undertaken for further developments of the proposed methodology are traced.

Research limitations/implications

The application of the method is based on the assumption that managers charged with the analysis have a profound understanding of the specific contextual factors which may determine a reaction of the organization to a performance indicator or a PMS. Furthermore, at the moment, the methodology does not consider the possibility of interaction among different indicators in producing the impact.

Practical implications

This paper may be used to guide the selection of the most appropriate PMS from the impact point of view. The proposed methodology can be very helpful instrument for an organization involved in the design of new PMSs. It guides the decision maker through the various phases: indicators definition, *analysis of their properties, impact analysis, and choice of the set with the preferable impact profile.*

Originality/value

The issue of impact has been long debated in literature. Many articles try to analyse the operative and strategic consequences of the introduction of a PMS in an organization. This paper proposes a methodology for a more structured and objective evaluation of the impact of new PMS before introducing it in a firm. This can result in a significant help for manager who have to find the best set of indicators for the performance evaluation of their organization or have to choose between two or more sets of indicator satisfying, in principle, the same representation objective.

Keywords

Quality Performance indicators, Performance Measurement System, PMS, impact assessment, Balanced Scorecard, BSC.

1. Introduction

Organizations implement Performance Measurement Systems (PMSs) in order to manage and assess their processes. The strategic goals are translated into indicators. In this way managers verify if targets are met, allocate resources and choose what strategy to implement.

In general, a PMS is introduced with the aim of satisfying a specific ‘representation-target’. A representation-target can be defined as the objective for what a ‘context’ (i.e. a manufacturing process, or a distribution/supply chain, or a market, or a result of a competition, etc.), or part of it, is modelled and represented by indicators in order to perform evaluations, make comparisons, formulate predictions, take decisions, etc... (Franceschini *et al*., 2006.b; 2007).

However, it can be shown that given a representation-target, the indicator (or set of indicators) relating to it is not unique (Roberts, 1979; Franceschini *et al*., 2006.b; 2007). In order to monitor a strategic goal, several alternative set of indicators or PMSs may be defined.

The main aim of this paper is to present a methodology able to support the selection of a PMS basing on the impact it may exert on the organization.

The selection of the most appropriate PMS or set of indicators is very critical (Oakes, 2008). In the design of the most representative PMS managers often consider properties such as coherence with the monitored goals, exhaustiveness, redundancy, level of detail, cost of data acquisition, simplicity of use, etc. (Caplice and Sheffy, 1994; U.S. Department of Treasury, 1994; Hulme, 2000; Performance Based Special Interest Group, 2001; Kennerly and Nelly, 2003; Franceschini *et al*., 2007; University of California, 2010; Abdullah *et al*., 2011; Marín and Ruiz-Olalla, 2011; Mehra *et* *al.*, 2011; Sampaio et al., 2011). However, this analysis may not provide enough information to chose what PMS implement.

For example, consider the R&D effectiveness index (EI), proposed by McGrath and Romeri (1994) given by the per cent of profit obtained from new products divided by the per cent of revenue spent on R&D. Hauser and Katz (1998) observe that R&D is a long-term investment. If managers and employees perceive that they are rewarded based on EI, then they will prefer projects that are less risky (and more short-term oriented). A significant fraction of R&D projects can be falsely rejected or falsely selected if EI is adopted. This subtle effect is the consequence of performance indicators impact.

Indicators always exert an impact on the actions and decisions of companies independently from the goal they are implemented. Whether indicators are simply used to monitor a specific process or explicitly introduced to enhance its performances, they affect the organization behaviour. Impact may occur just because an organization implement a set of indicators, regardless of the achieved values and the fixed goals. If counter-productive indicators are introduced, a negative impact is exerted. In this case, new indicators must be established but it is extremely hard to refocus the enterprise on new goals due to the typical inertia of monitored systems.

For this reason, impact analysis is mandatory for the selection of a PMS.

The way an organization behaviour is impacted by performance measurement is a debated issue. Skinner identified in 1974 simplistic performance evaluation as one of the major causes of factories getting into trouble (Skinner, 1974). Hill also recognised the role and impact of PMS in his studies of manufacturing strategies (Hill, 1999).

Barnetson and Cutright analyse indicators used to monitor the performance of Canada higher education colleges. They recognize six different typologies of embedded assumptions in each indicator (value, definition, goal, causality, comparability, normalcy) which shape what we think and how we think about (Barnetson and Cutright, 2000).

In the no-profit sector the issue of impact has been recently addressed (Wainwright, 2002; Moxham and Boaden, 2007). Authors provide a review of the different methods for impact evaluation in the voluntary sector and recognize that no single tool measures the full spectrum of impact.

Neely proposes a research agenda for the next years in the field of performance measurement and recognizes a lack of empirical research on the impact of PMS on organizations (Neely, 2005).

Francos-Santos *et al*. classify the different definitions of business PMS in the literature. They identify "influence behaviour" as one of the key roles of these systems (Francos-Santos *et al*., 2007, Parast *et alii*, 2011).

In the last years, several works focused on different areas of finance and microfinance presented specific approaches for evaluating indicators impact from that point of view (Hulme, 2000; Abdullah *et al.*, 2011; Mehra *et al.*, 2011; Jacob et al., 2012).

Recently, an interesting review about contemporary PMSs has been presented by Franco-Santos *et al.* (2012). Basing on the analysis of a vast sample of empirical studies in the areas of accounting, operations and strategy, the authors proposed a framework of classification based on three categories: people's behaviour, organizational capabilities and performance consequences. Results presented in this work constitute an important starting point for constructing a reference model for impact evaluation of PMSs. Analogous papers were been previously presented by Micheli *et al.* (2011), Nudurupati *et al.* (2011) and Tung *et. al* (2011).

Up to now, the research conducted in order to understand how PMSs impact organizations has not yet produced definitive results in terms of a structured methodology able to guide an organization in the selection of the correct PMS for their context.

Interesting approaches have been presented in the field of environmental impact (Pastakia and Jensen, 1998; Pennington et al., 2004; Ijas et al., 2010). Some models for impact analysis of business decisions on the environment, together with some examples of evaluation scales are also presented and discussed in Zhou and Schoenung (2007). However, the impact of performance indicators on organizations is a complex issue hardly quantifiable. It is strictly dependent on the internal (e.g. cultural values, size, resources) and external (e.g. socio-economical) organizational context. The main aim of the present proposal is to suggest an approach to identify, during the design of a new PMS in an organization, which of the specific organizational dimensions are actually impacted and evaluate if an overall positive or negative effect is occurred.

The method is based on a reference model which identifies the different impact areas within an organization. Then techniques to support impact evaluation and consequently the selection of an appropriate PMS are introduced.

In detail, the paper is structured as follows. Section 2 proposes a reference model for impact assessment. Section 3 introduces a methodology for impact evaluation. In order to explain the different steps of the methodology, application examples are given. Section 4 presents strengths and limitations of the proposed approach. Finally, Section 5 sums up the main results of the contribution.

2. A reference model for impact assessment

This Section focuses on the definition of a reference framework to exhaustively depict the phenomenon of impact within an organization. In Table 1 a list of the main factors proposed in the literature for impact analysis is reported (Bourne and *et al*. 2005; Franceschini *et al*., 2012).

Table 1: Main factors for impact analysis proposed in the literature (Bourne *et al*., 2005; Franceschini *et al*., 2012).

Impact factor	References
PMS maturity	Bititci *et al*., 2000; Evans, 2004; Andersen and Jessen, 2003
Organizational size	Hoque and James, 2000; Hudson *et al*., 2001
Organizational structure	Hudson *et al*., 2001; Nahm *et al*., 2003; Garengo and Bititici, 2007
Resources	Hudson *et al*., 2001; Kennerly and Neely, 2002; Heo and Han, 2003; Greatbanks and Tapp, 2007; Garengo and Bititici, 2007; Forslund, 2007
Organizational culture	Cameron and Quinn, 1999; Henry, 2006
Management style	Hudson *et al*., 2001; Schein, 2004; Ukko *et al*., 2007; Garengo and Bititici, 2007; Dossi and Patelli, 2008; Forslund, 2007
Strategic alignment	Atkinsons, 1998; Greatbanks and Tapp, 2007; Norreklit, 2000; Chenhall, 2005
Performance measures format	Lipe and Salterio, 2002
Data gathering, analysis and communication	Kerssens-van Drongelen and Fisscher, 2003; Chenhall, 2005
Business model	Hudson *et al*., 2001; Garengo and Bititici, 2007

From an analysis of these literature proposals, which are all worth of consideration for their contribution to the debate on the topic of impact, it is possible to observe that:

- Impact factors are scarcely operational. They are often considered as contextual factors which induce a positive or negative impact in a specific environment but a general procedure to evaluate impact is not suggested.
- Often impact factors are not clearly identifiable. For example, classifying the culture which prevails within an organization is not an easy task.
- Overall, impact factors are not independent. For example, factors characterizing impact in Small and Medium Enterprises (SMEs) include resources and organizational structure (Hudson *et al*., 2001) which may not be considered as independent perspectives.

The main consequence of these criticalities is that different PMSs or sets of indicators can not be compared from the impact point of view. If there is no operational procedure to assess impact, it is not possible to select a PMS according to the impact it exerts.

An operational framework to identify the whole effects of performance measures on organizations is then required. This framework may originate from Kaplan and Norton’s Balanced Scorecard (BSC) model (Kaplan and Norton, 1992; 1996; 2001), which is widely recognized to be a complete and balanced framework in describing organization performances (Biazzo and Garengo, 2012). It identifies four perspectives of analysis: *financial*, *internal business process*, *learning and growth*, and *customer* (Kaplan and Norton 1992; 1996; 2001).

Since BSC considers all the aspects of the performance life of an organization, it may be used as a reference model to identify the areas impacted by a PMS (Wu and Chen, 2012). The four perspectives of BSC are considered as the basic areas on which indicators may exert their impact. Then, a list of analysis criteria of impact are derived for each of these basic area. By this approach, BSC model is transformed into a reference model for impact analysis (see Figure 1). We define it as the BSC Impact Model (BSC-IM). The criteria built for a given organization remain valid over time and they may be used again to analyze impact when the existing PMS will be redesigned or new indicators will be introduced.

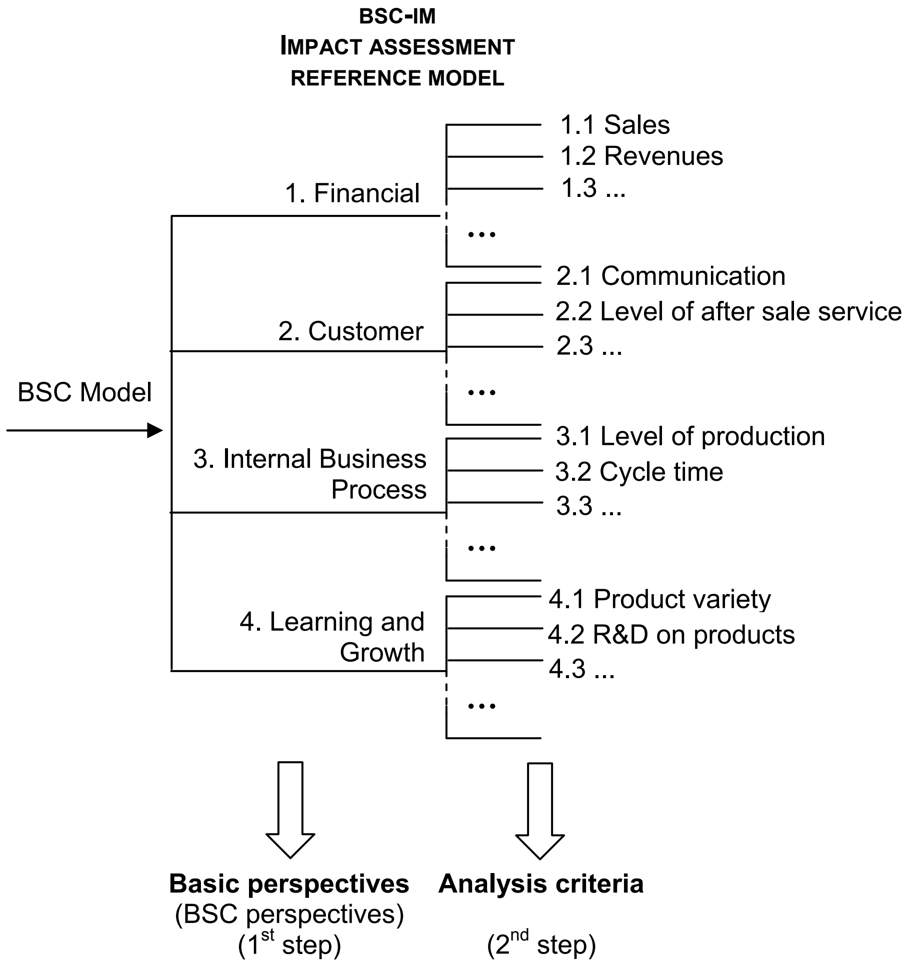

Figure 1 - Steps for the construction of the impact assessment reference model (BSC-IM). The four BSC perspectives (Kaplan and Norton, 1992; 1996; 2001) are interpreted as basic impact areas (1st step) which are subsequently split in a list of specific analysis criteria (2nd step). Here, as an example, a manufacturing organization is considered.

3. Impact analysis

BSC-IM is the basis of the procedure for impact analysis which is described in this Section. Before introducing the detailed steps of the methodology, a definition of impact is given. Adapting Wainwright's words (2002), impact may be defined as *any alteration of an organization behaviour resulting from the implementation of a PMS. It includes intended as well as unintended, negative as* *well as positive, and long term as well as short term effects*. In order to make this definition operational, the following macro-steps of impact analysis are introduced (see Figure 2):

1. identification of the alternative PMSs to be analyzed;
2. definition of a set of criteria for impact assessment (basing on the reference model BSC-IM);
3. analysis of each single indicator impact (*impact matrix*);
4. for each alternative PMSs, synthesis of the impacts of all the indicators (comparison of *impact profiles*);
5. adoption of the PMS with the preferable impact profile.

In the following each step is explained in detail.

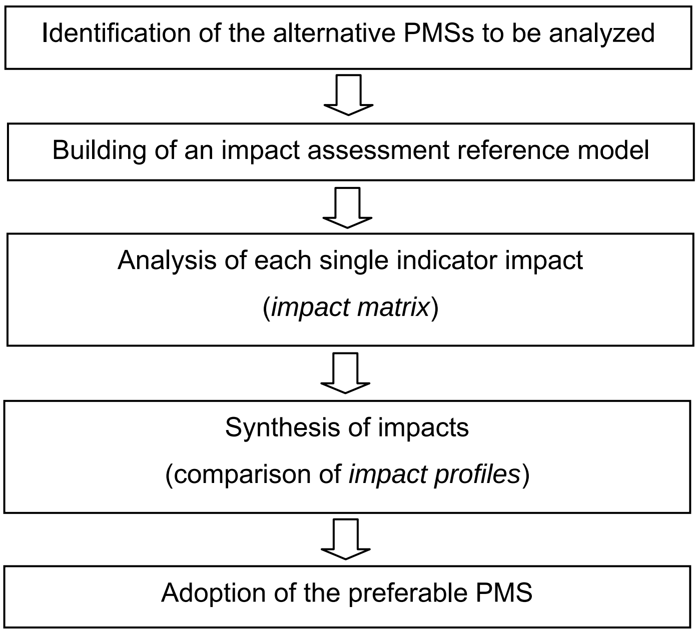

Figure 2 – Steps of the suggested methodology for impact analysis.

3.1 Identification of the alternative PMSs to be analyzed

The starting point of the proposed methodology consists in the identification of possible alternative sets of indicators (PMSs) satisfying the given representation-target.

As a preliminary step, each PMSs is analysed from the point of view of its basic properties. Table 2 shows a synthetic taxonomy of these properties (Franceschini *et al.*, 2007).

As a second course of action the impact exerted by each PMS is analysed. Suppose for example that an organization implements a Total Quality Management (TQM) system to improve its performance. In order to understand the effect of TQM practices (representation target), basing on the literature three alternative sets of indicators (or PMS) are proposed (see Table 3).

Top management analyses the three PMSs and find them all relevant for the monitoring of the considered goal. Indicators are all coherent with the representation-target, which is to understand the effect of TQM practices. In this case, in order to select the most appropriate PMS, the impact of the three sets of indicators must be analysed before their implementation on-the-field.

Table 2: Taxonomy of indicators properties (Franceschini *et al.*, 2007).

Properties of indicators		
General properties	Consistency with the representation target	The indicator should properly represent the representation-target.
	Level of detail	The indicator should not provide more than the required information.
	Non counter-productivity	Indicators should not create incentives for counterproductive acts.
	Economic impact	Each indicator should be defined considering the expenses to collect the information needed.
	Simplicity of use	The indicator should be easy to understand and use.
Properties of sets of indicators	Exhaustiveness	Indicators should properly represent all the system dimensions, without omissions.
	Non-redundancy	Indicators set should not include redundant indicators.
Properties of derived indicators	Monotony	The increase/decrease of one of the aggregated indicators should be associated to a corresponding increase/decrease of the derived indicator.
	Compensation	Changes of different aggregated indicators may compensate each other, without making the derived indicator change.
Accessory properties	Impact	For each indicator the impact on process should be carefully analysed.
	Long term goals	Indicators should encourage the achievement of process long-term goals.

Table 3 – Alternative sets of indicators (or PMS) for the evaluation of the effect of TQM practices.

Set 1 Flynn et al. (1995)
quality market outcomes
percent-passed final inspection with no rework
unit cost
fast delivery
volume flexibility
inventory turnover
cycle time

Set 2 Mohrman et al. (1995)
ROE
ROI
ROS
ROA
perceived profitability
perceived competitiveness
market share
cost of manufacturing
inventory turnover
perceived productivity
customer satisfaction
quality
speed

Set 3 Powell (1995)
sales growth
profitability
revenue growth
productivity
competitive position
revenues
overall performances

3.2 Definition of a set of criteria for impact assessment

The second step entails the definition of a set of criteria for impact assessment, specific for the considered organization, basing on the reference model (e.g. BSC-IM). As an example, consider the methodology for impact analysis developed for a generic manufacturing organization. According to the BSC-IM model, the list of criteria (see Table 4) is defined on the basis of the literature about performance measurement in manufacturing companies (Azadeh *et al*., 2007; Gosselin, 2005; Ghalayini *et al*., 1997).

Table 4 - Reference model for impact assessment of a generic manufacturing firm. The first column represents the basic perspectives (Kaplan and Norton, 1992; 1996; 2001). The second column shows the analysis criteria for the specific organization (Azadeh et al., 2007; Gosselin, 2005; Ghalayini et al., 1997). The last column reports criteria sense of preference, i.e. the direction which determine a strategic improvement from the organization point of view (↑: increasing sense of preference; ↓: decreasing sense of preference).

BSC IMPACT MODEL		
BASIC PERSPECTIVES	ANALYSIS CRITERIA	SENSE OF PREFERENCE
Financial	Sales	↑
	Revenues	↑
	Cost of human resources	↓
	Cost of raw materials, goods and external services	↓
	Other costs	↓
	Investments	↑
	Amount of debt	↓
Customer	Communication	↑
	After sale service	↑
	Perception of final product/service	↑
	Organization image	↑
Internal business process	Quantitative production level	↑
	Cycle time	↓
	Qualitative production level (final products)	↑
	Qualitative production level (incoming products)	↑
	Delivery	↑
	Stock level	↑
	Capacity utilization	↑
	Expansion	↑
	Satisfaction of human resources	↑
	Productivity of human resources	↑
	Security of human resources	↑
	Environmental impact	↓
Learning and growth	Product variety	↑
	Research and development on products	↑
	Research and development on process	↑
	Competitiveness	↑
	Response time	↑
	Conformity to customer requirements	↑
	Rationality in setting and development of projects	↑
	Education, training and qualification of human resources	↑
	Self-learning	↑

The BSC-IM criteria may have different *sense of preference*. In general, the sense of preference is the direction which determine a strategic improvement from the organization point of view. For example, referring to Table 4, the criterion ‘Costs of raw material, goods and services’ has a decreasing sense of preference since an increase of these costs is an inconvenience from the organization point of view. On the opposite, criterion ‘Qualitative production level of final product’ has an increasing sense of preference in the perspective of reducing the defective items. Increasing (↑) and decreasing (↓) senses of preference are reported in Table 4 next to each criterion.

3.3 Analysis of an indicator impact

Once an indicator is introduced, it may affect the organization behaviour. This means, according to the proposed reference model, that it may exert an impact on a given BSC-IM criterion.

The evaluation of impact is a complex matter involving several contextual factors which may be not standardized. Elements such as the prevailing organizational culture, specific collective agreements or previous investments in technologies should be considered case by case. Given this critical issue, a rational reaction of the organization is assumed. The decision maker is able to anticipate the reaction of the organization, basing its expectations on the know-how of the specific contextual factors.

Single indicators impact is evaluated by means of an ordinal scale (i.e. positive, negative or null impact). Long term and short term impacts are implicitly included in the meaning of positive or negative impacts.

The assessment of a single indicator impact is developed for each analysis criterion as follows:

a. Identify the indicator to be analysed.

b. Identify the analysis criterion and its sense of preference.

c. Forecast the organization reaction.

d. Identify the effect of the hypothesized reaction on the analysis criterion.

e. Detect a positive (P) or negative (N) impact.

The step which brings to the identification of a positive or negative impact may be formalized as follows. To represent the effect of the organization reaction on the considered criterion a second arrow is introduced: ‘↑’ for an increasing effect and ‘↓’ for a lowering one. The impact is positive (P) if there is an increasing effect on a criterion with an increasing sense of preference, or a lowering effect on a criterion with a decreasing sense of preference. Otherwise, the impact is negative (N). If there is no effect on the criterion the impact is null. The mathematical symbol “⊗”, appearing in the last column of Table 5, indicates the combination between the “criterion sense of preference” with the “effect of the organization reaction on the criterion” itself. Table 5 shows all the possible configurations which may generate a positive (P) or negative (N) impact.

In other similar contexts, such as for example in the analysis of environmental impact (Pastakia and Jensen 1998), wider ordinal scales are employed that take in consideration different ‘positiveness’ and ‘negativeness’ levels. As a preliminary approach, the proposal reported in this paper is that of evaluating the impact of each single indicator by means of an ordinal scale (i.e. positive, null or negative impact). At this stage the aim is obtaining a rough estimation of the impact exerted.

The choice of a three-level ordinal scale is suggested by the intrinsic nature of impact evaluation. It allows limiting ambiguities of interpretation, preserving the properties of empiricity and objectivity of a measurement (Roberts, 1979; Finkelstein, 1982; Franceschini *et al.*, 2007).

It follows that the mathematical operators employed for analysing and aggregating ordinal data should comply with their related properties (Roberts, 1979).

Table 5 - Reference table for the identification of positive or negative impact of an indicator. Column 1 shows the criterion sense of preference. Column 2 schematizes the effect on the criterion of the organization reaction to the indicator. The criterion may be subjected to an increasing (↑) or lowering (↓) effect. Column 3 shows impact evaluation. If, for a given criterion, both columns 2 and 3 present the same symbol, a positive (P) impact is obtained. Otherwise, the impact is Negative (N).

	COLUMN 1	COLUMN 2	COLUMN 3
Case number	**Criterion sense of preference**	**Effect of the organization reaction on the criterion**	**Positive/Negative impact**
(1)	↑	↑	↑⊗↑⇒ P
(2)	↑	↓	↑⊗↓⇒ N
(3)	↑	-	O
(4)	↓	↑	↓⊗↑⇒ N
(5)	↓	↓	↓⊗↓⇒ P
(6)	↓	-	O

Legend: P = Positive impact, N = Negative impact, O = Null impact; symbol ⊗ indicates the combination between the “criterion sense of preference” with the “effect of the organization reaction on the criterion” itself.

Consider again, for example, the set of indicators proposed by Flynn *et al*. for the monitoring of the effect of a TQM practices (see Set 1 of Table 3). In order to verify if TQM approach improve the product cycle time, the indicator ‘cycle time’ is introduced. Decision makers hypothesize that if the purpose of evaluation is declared, the workers will try to work as fast as possible but more defective items will be produced. Management wants to verify the effect of this indicator on criterion ‘Qualitative production level (final product)’ with a increasing sense of preference (i.e. the organization wants high quality product). In this case, the qualitative level of final products reduces since more defective items are realized (see Table 6). As a consequence, from the combination between the “criterion sense of preference” with the “effect of the organization reaction on the criterion” itself, a negative impact occurs.

Table 6 - Impact analysis of indicator 'cycle time' on the criterion 'Qualitative production level (final product)'.

Step 1	Step 2	Step 3	Step 4	Step 5
Indicator	**Analysis criterion sense of preference**	**Organization reaction to the indicator**	**Effect of the organization reaction on the criterion**	**Impact**
Cycle time (average cycle time)	Qualitative production level (final product) Increasing sense of preference: ↑ A high quality of final products is preferable	Quality of final products reduces since decreasing the cycle time determines an increasing of defective items	Qualitative production level (final product) Decreasing effect: ↓ Quality of final products reduces	↑⊗↓ ⇓ **N** Negative impact

At the end of the procedure, the so called *impact matrix* is obtained. Impact matrix is a table which gives an overview of the impact exerted by an entire set of indicators on each criterion (see Figure 3). The impact matrix allows:

- Obtaining a picture of the impact on all the organizational perspectives.
- Obtaining a first rough information on the impact exerted by specific indicators observing single *impact records*. In this case the most critical indicators may be preliminarily identified.
- Highlighting the *cross impact* of each indicator. An indicator may exert an impact on different organizational perspectives as shown by its *impact record* (see Figure 3). For example, indicator 'fast delivery' by Flynn *et al*. (see Table 3) has a negative impact on the criterion 'Cost of raw materials, goods and external services' (Financial perspective of the BSC-IM) but a positive impact on criterion 'Competitiveness' (Learning and Growth perspective of the BSC-IM) since shorter delivery times make the organization more competitive on the market.

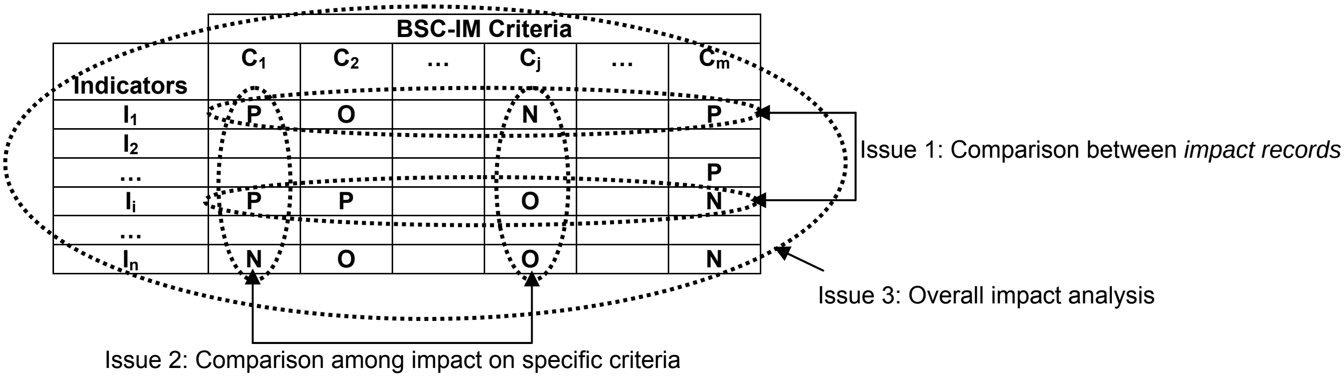

Figure 3 – *Impact matrix*. Rows represent the *impact records* obtained for each single indicator of a PMS. Columns represent the impact exerted by a set of indicators on each single analysis criterion.
Legend: P: Positive impact; O: Null impact; N: Negative impact.

Information contained in the impact matrix can be utilized for different applications:

1. The comparison of impacts of each single indicator on all criteria (comparison between *impact records*).
2. The comparison of the impact of a set of indicators on specific analysis criteria.

3. The comparison of the overall impact of two or more sets of indicators.

The second and the third topics will be the subject of the following Sections.

Table 7 and Table 8 show respectively the assessment of each indicator impact and the impact matrix of Set 1 by Flynn *et al*. (Table 3). For the sake of simplicity, only a subset of the criteria reported in Table 4 is considered. Appendices A.1 and A.2 report the analyses for all the three sets of indicators of Table 3.

Table 7 – Analysis of impact of sets of indicators for the evaluation of the effect of TQM practices on organizations (as an example, only Set 1 by Flynn *et al*. is reported). For each criterion: the first column shows the criterion sense of preference, the second one schematizes the organization's reaction to the indicator; the third one shows the impact exerted by the considered indicator obtained by the comparison of the first two columns.
Legend: P: Positive impact; O: Null impact; N: Negative impact.

	PERSPECTIVES OF THE BSC-IM																										
	FINANCIAL									INTERNAL BUSINESS PROCESS												CUSTOMER			LEARNING AND GROWTH		
	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9		
Flynn et al. (1995)	Sales			Cost of raw materials, goods and services			Investments			Cycle time			Qualitative production level (final product)			Stock level			Productivity of human resources			Perception of final product			Competitiveness		
SET 1 – quality market outcomes		↑	P		0	O		0	O		↑	P		↑	P		0	O		0	O		↑	P		↑	P
SET 1 – percent-passed final inspection with no rework		0	O		0	O		↑	P		↑	P		↑	P		0	O		0	O		0	O		0	O
SET 1 – unit cost		0	O		↓	P		0	O		0	O		↓	N		↑	P		0	O		0	O		↑	P
SET 1 – fast delivery	↑	↑	P	↓	↑	N	↑	0	O	↑	↑	P	↑	0	O	↑	0	O	↑	0	O	↑	0	O	↑	↑	P
SET 1 – volume flexibility		↑	P		↓	P		0	O		↑	P		0	O		0	O		0	O		0	O		↑	P
SET 1 – inventory turnover		0	O		0	O		0	O		↑	P		0	O		↑	P		0	O		0	O		↑	P
SET 1 – cycle time		0	O		0	O		↑	P		↑	P		0	N		0	O		↑	P		0	O		↑	P

Table 8 - *Impact matrix* of sets of indicators for the evaluation of the effect of TQM practices on organizations (as an example, only Set 1 by Flynn *et al*. is reported). At the bottom of the table the impact profile is reported. Three profiles are obtained using different techniques to synthesize impact on each BSC-IM criterion.
Legend: P: Positive impact; O: Null impact; N: Negative impact.

	PERSPECTIVES OF THE BSC-IM								
Flynn et al. (1995)	FINANCIAL			INTERNAL BUSINESS PROCESS				CUSTOMER	INNOVATION AND LEARNING
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
	Sales	Cost of raw materials, goods and services	Investments	Cycle time	Qualitative production level (final product)	Stock level	Productivity of human resources	Perception of final product	Competitiveness
SET 1 – quality market outcomes	P	O	O	P	P	O	O	P	P
SET 1 – percent-passed final inspection with no rework	O	O	P	P	P	O	O	O	O
SET 1 – unit cost	O	P	O	O	N	P	O	O	P
SET 1 – fast delivery	P	N	O	P	O	O	O	O	P
SET 1 – volume flexibility	P	P	O	P	O	O	O	O	P
SET 1 – inventory turnover	O	O	O	P	O	P	O	O	P
SET 1 – cycle time	O	O	P	P	N	O	P	O	P
Impact profile - Impact simple scoring 'maximum positive impact'	3	2	2	6	2	2	1	1	6
Impact profile - Impact simple scoring 'minimum negative impact'	0	1	0	0	2	0	0	0	0
Impact profile - No low impact ranking	**O**	**N**	**O**	**P**	**N**	**O**	**O**	**O**	**P**

3.4 Impact synthesis

The overall impact analysis (see Figure 3) requires a synthesis of the information contained in the impact matrix. Impact synthesis entails two sub-steps:

1. synthesis on each BSC-IM criterion;
2. overall impact synthesis for the comparison of more *impact profiles*.

An impact profile is a record $S = \{S_1, S_2, \ldots, S_j, \ldots, S_m\}$, being S_j the impact synthesis on a single criterion j ($j = 1, \ldots m$) (see Figure 3, Issue 2).

In the following two different approaches to build an *impact profile* are presented:

1. Impact simple scoring;
2. Ordinal impact ranking.

Pros and cons of each technique are analyzed.

Sections 3.4.1 – 3.4.2 propose possible approaches to obtain an impact profile, while Section 3.4.3 gives some ideas for the overall impact synthesis.

3.4.1 Impact simple scoring

This rough technique considers the scoring of impacts on each single BSC-IM criterion. The procedure of synthesis is based on the count of "Ps" (positive impacts) and "Ns" (negative impacts) in each single column of the impact matrix. If the goal of impact analysis is to identify the maximum positive impact, the number of "Ps" for each column is considered. On the contrary, if impact analysis aims at identifying the minimum negative impact, the number of "Ns" impacts may be analyzed, and so on. Examples of *impact profiles* obtained considering this simple synthesis technique are reported at the bottom of Table 8. The highest positive impact (6 positive impacts) is exerted on criteria 'Cycle time' and 'Competitiveness'. Impact profiles for the three sets of indicator for the evaluation of TQM impact on organization performances are reported in Appendix A2. Here it is possible to see, for example, that Set 3 (Powell, 1995) exerts the highest positive impact on criterion 'Sales' while the criterion 'Competitiveness' is one of the most positively impacted by all the three compared sets.

3.4.2 Ordinal impact ranking

This section proposes evaluating the impact of each single indicator by means of an ordinal scale (i.e. positive, null or negative impact). The choice of a three-level ordinal scale is suggested by the intrinsic nature of impact evaluation. It allows limiting ambiguities of interpretation, and preserving the properties of empiricity and objectivity of a measurement (Roberts, 1979; Finkelstein, 1982; Franceschini *et al.*, 2007).

The impact simple scoring technique does not consider the whole information included in each single column of an *impact matrix*. For example, if the goal of impact analysis is to identify the maximum positive impact and the percentage of positive impacts is calculated, the technique does not take into account the presence of negative or null impacts. A set of five indicators which exerts the impacts P, P, O, O, O on a criterion, has the same synthesis value of a set with P, P, N, N, N impacts on the same criterion.

When the evaluation scale of impact holds ordinal properties, often a numerical conversion is done (e.g. “P”= 3; “O”= 2; “N”= 1). This approach is adopted, for example, in the field of environmental impact evaluation (Rau and Wooten, 1980; Morris and Therivel, 2009). This practice, even if it simplifies the subsequent analysis, gives rise to two basic problems:

- the numerical codification converts the ordinal scale into a cardinal one. The method introduces some properties (the “distance” for example) that were not present in the original ordinal scale.
- The numerical codification is arbitrary. Changing the numerical encoding may determine a change in the obtained results.

Many works in literature show how an improper cardinal codification of ordinal data may results in contradictory conclusions (Roberts, 1979; Franceschini *et al*., 2005; Franceschini *et al*., 2006.a). Data expressed on ordinal scale need to be aggregated using specific operators (Roberts, 1979). Many studies tried to find specific approaches for data analysis and aggregation, simple measures of central tendency such as the mode or the median value may be used. An deep review of usable operators is reported in Franceschini *et al*., (2005). Among them, an interesting approach for impacts aggregation is the ‘no low’ rule (Franceschini *et al*., 2005). It considers negative impacts as the most critical and operates as follows:

$$S_j = \begin{cases} \mathrm{N} & if\ \exists\ m_{ij} = N \quad \forall i = 1,...,n \\ else & \mathrm{mode}\{m_{ij}\} \quad \forall i = 1,...,n \end{cases}$$

where S_j is the synthesis of impact on an analysis criterion j (j =1, …, m) and m_{ij} is the impact of indicator i (i =1, …, n) on criterion j (see Figure 3). According to this rule (‘*no low’ impact ranking*), if just a negative impact (N) is exerted, then the synthesis value of impact is ‘N’, else S_j is given by the modal value of impacts on criterion j. In presence of a multimodal distribution of impacts on a criterion, S_j is given by lowest impact (i.e. null impact ‘O’). The *no low impact ranking* technique may be applied when negative impact is considered very critical by a decision makers. This is often the case since negative impacts should be carefully avoided (see the example on indicator EI in Section 1).

Table 8 shows the impact profile for Set 1 by Flynn *et al*. applying the 'no low' impact ranking. By this rule the synthesis on criterion C_1 ('Sales') is given by 'O' (null impact) since there are no negative impacts and the most frequent value is 'O'. On the opposite, the synthesis of impact on criterion C_2 ('Cost of raw materials, goods and services') is 'N' since there is a negative impact by indicator 'fast delivery'. A negative impact is present also on criterion C_5 'Qualitative production level (final product)'. Analyzing the impact profile, decision makers may observe that Set 1 by Flynn *et al.* has a negative effect both on costs and quality of products. Just basing on this preliminary information, some indicators could be modified in order to reduce negative impacts.

Appendix A2 shows impact profiles for the three sets of indicators of Table 3.

It may be interesting also to consider the weights of indicators in the synthesis of their impact. Weights could reflect the costs of indicators acquisition and analysis as well as their strategic importance assigned by management. In this case, impact simple scoring technique may be applied. However, if the ordinal properties of impact are considered, more complex synthesis operators are required. As an example, the OWA operators can be considered (Yager and Filev, 1994; Yager, 2004; Yager *et al.*, 2011). These aggregation operators, based on the fuzzy logics, do not require a numerical codification of ordinal scale levels. Due to this basic characteristic, they are widely employed in many different field ranging from social to engineering applications. An interesting review about these operators is reported in Yager *et al.* (2011).

3.4.3 Overall impact synthesis

In order to obtain an overall impact evaluation (see Issue 3 of Figure 3), a last step is required. Information contained in each impact profile is synthesized in order to easily compare different PMSs or sets of indicators. To support this activity, an *impact chart* is built.

An impact chart is a multi-axis graph, where each axis represents the evaluation associated to a specific BSC-IM criterion (see Figure 5).

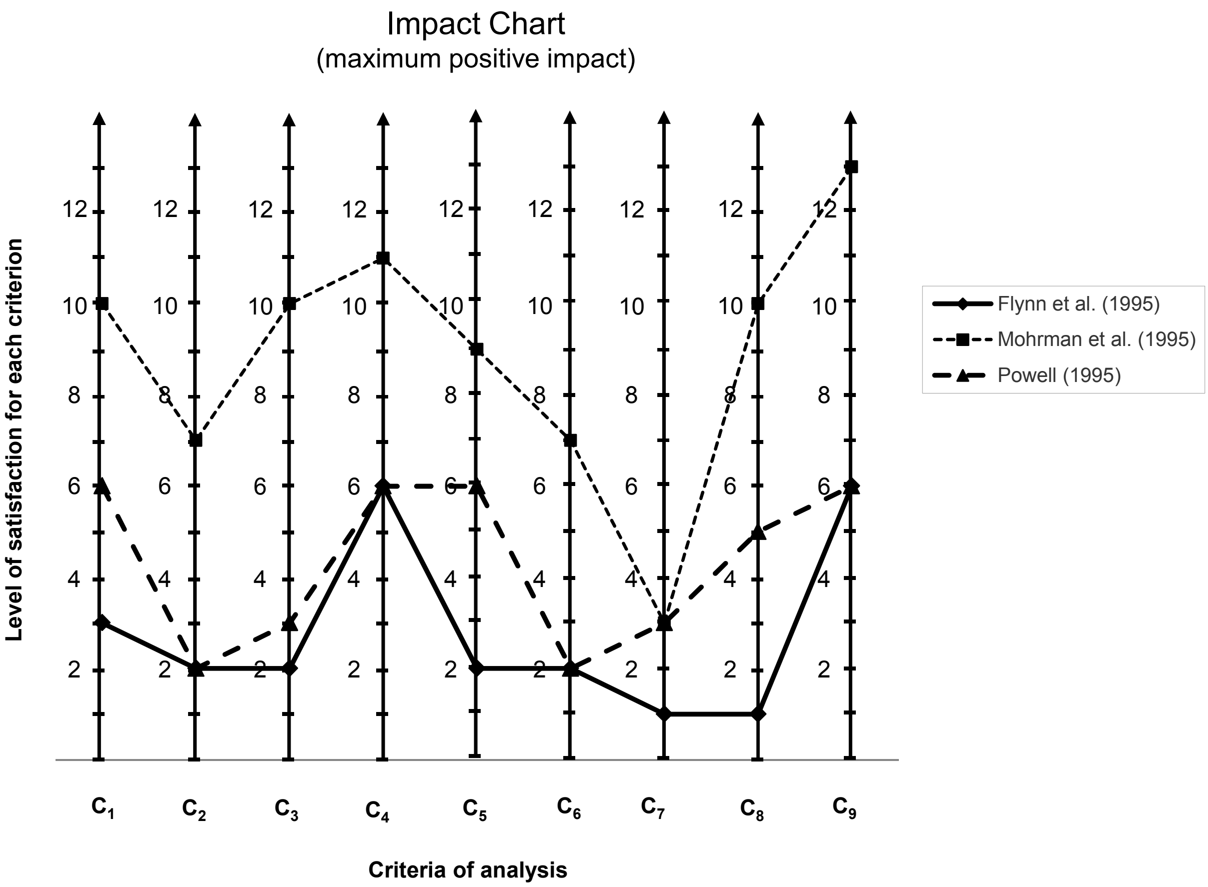

Figure 5 – Example of an *impact chart* for the three different sets of indicators reported in Table 3. Each axis corresponds to a BSC-IM criterion. The impact profiles of the three sets of indicators have been obtained using the 'maximum positive impact' simple scoring (see Appendix A.2). In this case, the result of the comparison is automatically achievable since Flynn *et al.* (1995) impact profile dominates Mohrman *et al.* (1995) profile, which in turn dominates Powell (1995) profile.

The comparison among different PMSs or sets of indicators is transformed in a comparison among impact profiles. Again, appropriate tools can adequately support this analysis. See for example MultiCriteria Decision Methods (MCDM) or Multi Criteria Decision Aiding (MCDA) methods (Vincke, 1992; Roy, 1996; Ehrgott, 2010; Pedrycz *et al.*, 2011).

4. Strengths and limitations of the proposed methodology

A list of the main pros of the proposed methodology is the following:

- Impact is one of the most critical aspect of PMSs. The proposed approach's aim is to support management in the identification of indicators positive and negative impacts and to synthesize the overall effect. It provides a set of structured steps to select the most relevant PMS or set of indicators according to its impact.
- It is based on a widely recognized reference model (BSC) which drives the identification of the impact areas within an organization. Each BSC perspective is further enriched by detailed analysis criteria.

- Even if the BSC is recognized as a complete framework for describing the main organizational areas, it is not unique. Operational criteria for impact analysis may be identified also basing on other models (e.g. EFQM) (EFQM, 2010), which managers consider suitable to represent their own organization. Procedure and synthesis methodologies proposed are still valid.

On the opposite, the main cons are:

- Management must be able to consider all the specific contextual factors which may determine a reaction of the organization to an indicator.
- At the present, the proposed methodology does not consider potential interactions among indicators. We think that this problem can be useful approached by tools similar to those used for the construction of the correlation matrix in the QFD (Quality Function Deployment) framework (Franceschini, 2001; Franceschini F., Rossetto S. 1998). Future works will consider this issue.

5. Conclusions

PMSs are usually introduced by organizations in order to monitor the achievement of goals, to allocate resources and/or to implement a management strategy.

The identification of the “right” performance measures is one of the most critical issues. Usually different sets of indicators are evaluated and filtered on the basis of their properties, the context of application, and the goal for which they are used. Very often they are also used for inducing a specific reaction in the organization in order to increase or improve its performance. In any case, it is commonly accepted that PMSs exert an impact, whatever positive or negative, on the contexts in which they are applied.

This paper introduces an operational methodology to evaluate indicators impact during the phase of design of a PMS.

In the framework of the proposed methodology, with the aim of obtaining a comprehensive picture of impact within an organization, a reference model for impact assessment is introduced. This is based on the Kaplan and Norton’s Balanced Scorecard perspectives which are interpreted as the basic impact areas.

The methodology analyses the impact that a set of indicators exerts on the basic impact areas for a given context. Specific tools are also introduced in order to verify if a positive or negative impact is exerted. In particular, the so called impact matrix is used for synthetizing the information coming from the analysis. The result of this activity is an impact profile for each set of indicators, which can be used for comparisons with the profiles of other PMSs.

This can result in a significant help for organizations which have to find the best set of indicators for performance evaluation or have to choose between two or more sets of indicator satisfying, in principle, the same representation objective.

Even if the methodology is articulated in well-defined steps, its application requires a deep knowledge of the context and organization in which it is employed. All the specific contextual factors which may determine a reaction of the organization to an indicator must be considered and evaluated. Furthermore, as a first approximation, in the analysis no interaction between indicators is assumed. Future works will consider the way the correlation among indicators may be evaluated and included in impact analysis. Further developments will also investigate specific approaches to analyze and compare different impact profiles.

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Appendix A.1 Analysis of single indicators impact

	DIMENSIONS OF THE BSC-IM																										
	FINANCIAL									INTERNAL BUSINESS PROCESS												CUSTOMER			LEARNING AND GROWTH		
	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9		
Flynn et al. (1995)	Sales			Cost of raw materials, goods and services			Investments			Cycle time			Qualitative production level (final product)			Stock level			Productivity of human resources			Perception of final product			Competitiveness		
SET 1: quality market outcomes		↑	P		0	O		0	O		↑	P		↑	P		0	O		0	O		↑	P		↑	P
percent-passed final inspection with no rework		0	O		0	O		↑	P		↑	P		↑	P		0	O		0	O		0	O		0	O
unit cost		0	O		↓	P		0	O		0	O		↓	N		↑	P		0	O		0	O		↑	P
fast delivery	↑	↑	P	↓	↑	N	↑	0	O	↑	↑	P	↑	0	O	↑	0	O	↑	0	O	↑	0	O	↑	↑	P
volume flexibility		↑	P		↓	P		0	O		↑	P		0	O		0	O		0	O		0	O		↑	P
inventory turnover		0	O		0	O		0	O		↑	P		0	O		↑	P		0	O		0	O		↑	P
cycle time		0	O		0	O		↑	P		↑	P		0	N		0	O		↑	P		0	O		↑	P

	FINANCIAL									INTERNAL BUSINESS PROCESS												CUSTOMER			LEARNING AND GROWTH		
	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9		
Mohrman et al. (1995)	Sales			Cost of raw materials, goods and services			Investments			Cycle time			Qualitative production level (final product)			Stock level			Productivity of human resources			Perception of final product			Competitiveness		
SET 2: ROE		↑	P		↓	P		↑	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
ROI		↑	P		↓	P		↑	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
ROS		↑	P		↓	P		0	O		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
ROA		↑	P		↓	P		↑	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
perceived profitability		↑	P		↓	P		↑	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
perceived competitiveness		↑	P		↓	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P		↑	P
market share	↑	↑	P	↓	0	O	↑	↑	P	↑	↑	P	↑	↑	P	↑	0	O	↑	0	O	↑	↑	P	↑	↑	P
cost of manufacturing		0	O		↓	P		0	O		0	O		↓	N		0	O		0	O		0	O		↑	P
inventory turnover		0	O		0	O		0	O		↑	P		0	O		↑	P		0	O		0	O		↑	P
perceived productivity		0	O		0	O		↑	P		↑	P		0	O		0	O		↑	P		0	O		↑	P
customer satisfaction		↑	P		0	O		↑	P		↑	P		↑	P		0	O		0	O		↑	P		↑	P
quality		↑	P		↑	N		↑	P		0	O		↑	P		0	O		0	O		↑	P		↑	P
speed		↑	P		↑	N		↑	P		↑	P		0	O		↑	P		↑	P		↑	P		↑	P

	FINANCIAL									INTERNAL BUSINESS PROCESS												CUSTOMER			LEARNING AND GROWTH		
	C_1			C_2			C_3			C_4			C_5			C_6			C_7			C_8			C_9		
Powell (1995)	Sales			Cost of raw materials, goods and services			Investments			Cycle time			Qualitative production level (final product)			Stock level			Productivity of human resources			Perception of final product			Competitiveness		
SET 3: sales growth		↑	P		0	O		0	O		↑	P		↑	P		0	O		0	O		↑	P		↑	P
profitability		↑	P		↓	P		0	O		↑	P		↑	P		↑	P		0	O		↑	P		↑	P
revenue growth		↑	P		0	O		0	O		↑	P		↑	P		0	O		0	O		↑	P		↑	P
productivity	↑	0	O	↓	0	O	↑	↑	P	↑	↑	P	↑	0	O	↑	0	O	↑	↑	P	↑	0	O	↑	↑	P
competetitive position		↑	P		↓	P		↑	P		↑	P		↑	P		0	O		↑	P		↑	P		↑	P
revenues		↑	P		0	O		0	O		0	O		↑	P		0	O		0	O		0	O		0	O
overall performances		↑	P		↑	N		↑	P		↑	P		↑	P		↑	P		↑	P		↑	P		↑	P

Notes to Tables in Appendix A.1

For each criterion:

- the first column shows the criterion sense of preference;
- the second one schematizes the organization’s reaction to the indicator;
- the third one shows the impact exerted by the considered indicator obtained by the comparison of the first two columns as described in Section 3.

Legend: P: Positive impact; O: Null impact; N: Negative impact.

Appendix A.2 Impact matrices

Flynn et al. (1995)

		DIMENSIONS OF THE BSC-IM								
		FINANCIAL			INTERNAL BUSINESS PROCESS				CUSTOMER	INNOVATION AND LEARNING
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
		Sales	Cost of raw materials, goods and services	Investments	Cycle time	Qualitative production level (final product)	Stock level	Productivity of human resources	Perception of final product	Competitiveness
SET 1	quality market outcomes	P	O	O	P	P	O	O	P	P
SET 1	percent-passed final inspection with no rework	O	O	P	P	P	O	O	O	O
SET 1	unit cost	O	P	O	O	N	P	O	O	P
SET 1	fast delivery	P	N	O	P	O	O	O	O	P
SET 1	volume flexibility	P	P	O	P	O	O	O	O	P
SET 1	inventory turnover	O	O	O	P	O	P	O	O	P
SET 1	cycle time	O	O	P	P	N	O	P	O	P
	Impact profile - Impact simple scoring 'maximum positive impact'	3	2	2	6	2	2	1	1	6
	Impact profile - Impact simple scoring 'minimum negative impact'	0	1	0	0	2	0	0	0	0
	Impact profile - No low impact ranking	**O**	**N**	**O**	**P**	**N**	**O**	**O**	**O**	**P**

Mohrman et al. (1995)

		DIMENSIONS OF THE BSC-IM								
		FINANCIAL			INTERNAL BUSINESS PROCESS				CUSTOMER	INNOVATION AND LEARNING
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
		Sales	Cost of raw materials, goods and services	Investments	Cycle time	Qualitative production level (final product)	Stock level	Productivity of human resources	Perception of final product	Competitiveness
SET 2	ROE	P	P	P	P	P	P	O	P	P
SET 2	ROI	P	P	P	P	P	P	O	P	P
SET 2	ROS	P	P	O	P	P	P	O	P	P
SET 2	ROA	P	P	P	P	P	P	O	P	P
SET 2	perceived profitability	P	P	P	P	P	P	O	P	P
SET 2	perceived competitiveness	P	P	P	P	P	O	P	P	P
SET 2	market share	P	O	P	P	P	O	O	P	P
SET 2	cost of manufacturing	O	P	O	O	N	O	O	O	P
SET 2	inventory turnover	O	O	O	P	O	P	O	O	P
SET 2	perceived productivity	O	O	P	P	O	O	P	O	P
SET 2	customer satisfaction	P	O	P	P	P	O	O	P	P
SET 2	quality	P	N	P	O	P	O	O	P	P
SET 2	speed	P	N	P	P	O	P	P	P	P
	Impact profile - Impact simple scoring 'maximum positive impact'	10	7	10	11	9	7	3	10	13
	Impact profile - Impact simple scoring 'minimum negative impact'	0	2	0	0	1	0	0	0	0
	Impact profile - No low impact ranking	**P**	**N**	**P**	**P**	**N**	**P**	**O**	**P**	**P**

Powell (1995)

		DIMENSIONS OF THE BSC-IM								
		FINANCIAL			INTERNAL BUSINESS PROCESS				CUSTOMER	INNOVATION AND LEARNING
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
		Sales	Cost of raw materials, goods and services	Investments	Cycle time	Qualitative production level (final product)	Stock level	Productivity of human resources	Perception of final product	Competitiveness
SET 3	sales growth	P	O	O	P	P	O	O	P	P
SET 3	profitability	P	P	O	P	P	P	O	P	P
SET 3	revenue growth	P	O	O	P	P	O	O	P	P
SET 3	productivity	O	O	P	P	O	O	P	O	P
SET 3	competetitive position	P	P	P	P	P	O	P	P	P
SET 3	revenues	P	O	O	O	P	O	O	O	O
SET 3	overall performances	P	N	P	P	P	P	P	P	P
	Impact profile - Impact simple scoring 'maximum positive impact'	6	2	3	6	6	2	3	5	6
	Impact profile - Impact simple scoring 'minimum negative impact'	0	1	0	0	0	0	0	0	0
	Impact profile - No low impact ranking	**P**	**N**	**O**	**P**	**P**	**O**	**O**	**P**	**P**

Legend: P: Positive impact; O: Null impact; N: Negative impact.